PATENT SPECIFICATION

845,240

Date of Application and filing Complete Specification: December 2, 1957. *No. 37507/57.*

Application made in France on November 30, 1956

Complete Specification Published: August 17, 1960

Index at Acceptance:—**Class 39(1)**, D1(D9A:D12:F4:J2:N3), D(8:9A:12B1:12B3:12B4:12B6:18B:31:38).

International Classification:—H01j.

COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Ionic Discharge Devices

We, SOCIETE D'ELECTRONIQUE ET D'AUTOMATISME, of 138, Boulevard de Verdun, Courbevoie, Seine, France, a French Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to improvements in gas or vapour filled discharge devices which operate by the initiation and maintenance of a plasma between a cathode and an anode included within a bulb filled with such an atmosphere. The term "plasma" as used herein relates to that part in space of a gas or vapour atmosphere wherein exists a high and substantially equal concentration of positive and negative charges, viz. of electrons and ions.

According to the present invention, we provide a self-relaxation oscillatory device comprising a gas or vapour plasma discharge tube having a sealed envelope containing a gas or vapour atmosphere, at least an anode and a cathode across which is established a potential difference which is low with respect to the ionization potential of the said atmosphere in a circuit including at least one series load, at least one condenser element, one plate of which is in contact with the said atmosphere, and the other plate of which, not contacting the said atmosphere, is connected to the cathode of the said tube and, within the said condenser element, a beta particle emitter material ensuring a permanent transfer of electrical charges from the condenser plate connected to the cathode of the tube to the other plate upon which are stored the said electrical charges until ionization of the said atmosphere occurs between the said charged plate and the said cathode.

From the permanent transfer of electrical charges across the said condenser plates and their accumulation on the receiving plate, the potential difference across the cathode and that plate of the condenser contacting the said atmosphere reaches the ionization value of the said atmosphere so that the required plasma will be initiated. The electrical resistance of the atmosphere will suddenly drop as, as is well known, such a plasma is a quite good conductor or, in other words, the resistance of the said plasma is quite low; the condenser will rapidly discharge through the plasma and consequently a current of high intensity circulates through the said plasma across the cathode to anode path of the tube and, consequently also, through any load circuit inserted in series between the cathode and anode. The discharge of the condenser will bring the potential of the plate in contact with the said atmosphere to a low value and the ionization of the atmosphere will be interrupted. Since the transfer of electrical charges is continuous, the thus-described process will repeat and consequently the tube will act as a self-sustained relaxation oscillator device.

One embodiment of the present invention will now be described with reference to the accompanying drawings in which

Fig. 1 is a cross sectional view of a discharge tube and

Fig. 2 is a cross sectional view (taken at 90° from Fig. 1) of a condenser element of the discharge tube shown in Fig. 1.

The discharge tube comprises an envelope or vessel 1 containing a cathode made of a rod or cylinder 2 coated with an electron emitting layer 3 and an anode 4 coaxial to the cathode and practically surrounding the cathode. For most applications the cathode will be of the cold cathode type, but thermionic cathodes may be used when very high

[Price 3s. 6d.]

powers are required from the device. The anode 4 is not a complete cylinder and a condenser is mounted in the gap. This condenser is shown in greater detail in Fig. 2, and comprises an outer cylindrical member 7 constituting one plate, an inner coaxial member 5 constituting the other plate and, over the inner face of the cylindrical member 5 is deposited a coating of a radio-isotope 6 of the kind which emits a beta ray emission. Obviously for the sake of clarity, the thicknesses of the element have been grossly exaggerated.

An electrical conductor 8 connects the cathode to the inner plate 5 of the said condenser. Such a connection may be made either inside the envelope of the discharge tube or outside the tube. The seals and spacers are omitted on the drawing, for the sake of simplicity, all being of a well known design.

The condenser being of a coaxial structure, insulating plates 12 and 13 together with the conducting rod 8 are used for supporting the structure. Conducting members 14 and 15 connect the rod 8 to the inner plate 5 and support this plate therefrom. The plates 12 and 13 support the outer plate 7 through vacuum-tight joints and the conductor 8 is also vacuum-tightly sealed through these plates, which may be made of ceramics or glass. The inside of the condenser is evacuated by any suitable process. The use of an evacuated vacuum-tight condenser is not imperative per se, since a solid-state dielectric condenser may be used (for example condensers having a dielectric of glass, mica or an organic material). However it is thought preferable to use an evacuated vacuum-tight condenser as being of lesser volume for a corresponding value. It is apparent that the capacity of the condenser is one of the factors which govern the recurrence frequency of the self-oscillation of the device.

The inner plate 5 is constituted by a thin nickel cylinder of about 25 microns in thickness. Over the inner face of the member 5 is deposited a coating of a radio-isotope which emits beta rays. The use of beta rays is provided in order to facilitate the handling of such a radio-isotope. It may be coated as a pure element, for example by a thermal evaporation process, or as a salt, by a chemical reaction of the said isoptope with the material of the wall of 5 or else by a precipitation or sedimentation process. The choice of a suitable radio-isotope depends on the estimated life of the discharge tube. Radio-isotopes have a very wide range of useful lives, for example thallium 204 has a useful life of 2.7 years, silicon 31 has a useful life of 14 years, and so forth.

Whatever radio-isotope is used, the deposit need only be a thin film of this substance, at 6, and the particles therefrom pass through the thin wall 5 which has only a small absorption coefficient for the said particles. When nickel is used with the above defined thickness, the said absorption factor is lower than 10%. The beta particles pass through the dielectric of the condenser and reach the plate 7 with a high velocity. The electrical charges from the beta particles are deposited on the said outer plate 7 and the storing of these electrical charges increases the potential of the said plate 7 until the ionization potential difference of the atmosphere of the tube across the cathode and the said plate is reached.

An arcuate shield 11 is provided on the inside of the envelope 1 of the discharge tube so as to protect the envelope opposite the gap in the anode 4.

Across the cathode and anode of the tube is applied a potential difference determined by the voltage of a battery 9. This potential difference, as stated, does not require to be high. If the discharge tube is filled with either mercury or cadmium vapor ,the potential difference may be lower than 6 volts; for hydrogen, nitrogen, argon, krypton or xenon, it may be lower than 12 volts; and for helium or neon, it may be lower than 24 volts. The anode potential does not interfere with the initiation and maintenance of the plasma within the tube but only determines the quantity of current passing through the said plasma controlled by the potential difference between the anode and the cathode. This plasma will be of extremely low resistivity any time it is in existence due to the relaxation operation of the tube. The device being described may be considered as acting as a converter of a low D.C. voltage into an A.C. voltage through a purely electronic process. The meaning of "A.C." is here quite broad since it relates to a relaxation oscillation so that the voltage collected across a resistive load connected in series in the anode to cathode circuit of the tube has a saw-toothed waveform. However, as known, the deionization time interval of a gas or vapour filled tube is far from negligible, which has the effect of rendering the saw teeth less asymmetrical in the waveform thereof. Such a phenomenon is usualy considered as a drawback of conventional tubes for switching purposes but for some purposes at least it is an advantage which may be enhanced by introducing a certain amount of metastable gas within the bulb of the tube. The collected waveform then approaches a triangular wave-shape, quite easy to convert into a substantially pure sine wave through the introduction of simple filtering means in the load circuits, when required. The

use of a transformer 10 which is shown on the drawing ensures such a result as the triangular wave-shape is "integrated" by the self-inductance of the primary of the said transformer.

The relaxation frequency is determined by the following factors:—capacity value of the condenser, transfer current (or leak resistance) across its plates and ionization potential value of the atmosphere within the tube. The transfer current depends, for a given weight of radio-isotope, on the load resistance constituted by the leak resistance across the condenser plates, otherwise termed the "parallel" resistance of the condenser. Further it depends on the activity characteristics of the isotope. Consequently, in designing the device, one may either compute the recurrency of the discharge per microgram of a determined isotope or, conversely, the weight of a determined isotope necessary for obtaining a required recurrence frequency, all other conditions being identical. Illustratively, and in order to emphasize the smallness of the weight of radio-isotope which will usually be required in a device according to the invention, we may mention that a recurrence of one second is obtained with a microgram of silicon 31 with a capacity value equal to 10 picofarads and for an ionization potential equal to 100 volts of the atmosphere of the tube.

However, during the course of utilisation of such a tube, the recurrence frequency will be liable to vary, if the ambient temperature varies. When this is the case, the product volume times pressure within the tube will, as is well known, vary according to a linear relation with the external temperature. Of course, temperature deviations could only occur within a restricted range, for instance between $-40°$ and $+110°C$. Negative temperature coefficient condensers are known, and are linearly responsive to such changes of temperature. Consequently, such condensers may be used in a device according to the invention for maintaining at a constant value the recurrence frequency of operation within this range of temperatures. For instance, such a negative temperature condenser will be connected in shunt with respect to the condenser forming part of the structure of the discharge tube, leads being provided for such a connection from the plates 5 and 7 of the condenser of the tube through the envelope thereof. Of course, when such a correction is provided in the design of the tube, the temperature coefficient correcting condenser may be provided with the envelope of the tube.

From another point of view, it may be advantageous to be able to provide, when required, for an adjustment of the recurrence frequency of operation of the device. This may also be made by the shunt connection of an auxiliary condenser across the plates of the condenser of the tube, viz. across leads from the plates 5 and 7 of the said condenser passed through sealed joints in the envelope of the tube. It is only an adjustment which is to be contemplated here, and not truly a change of recurrence frequency within wide limits as, if the controlling capacity was the externally connected one, the efficiency of the device would be obviously reduced since the transfer and storing of electrical charges as imposed by the internal structure of the tube cannot be varied.

If desired, a control grid can be added within the tube.

WHAT WE CLAIM IS:—

1. A self-relaxation oscillatory device comprising a gas or vapour plasma discharge tube having a sealed envelope containing a gas or vapour atmosphere, at least an anode and a cathode across which is established a potential difference which is low with respect to the ionization potential of the said atmosphere in a circuit including at least one series load, at least one condenser element one plate of which is in contact with the said atmosphere and the other plate of which, not contacting the said atmosphere, is connected to the cathode of the said tube and, within the said condenser element, a beta particle emitter material ensuring a permanent transfer of electrical charges from the condenser plate connected to the cathode of the tube to the other plate upon which are stored the said electrical charges until ionization of the said atmosphere occurs between the said charged plate and the said cathode.

2. A device according to claim 1, wherein the dielectric of the said condenser element is a vacuum.

3. A device according to claim 1, wherein the dielectric of the said condenser element is a solid state dielectric such as glass, mica or an organic material.

4. A device according to claim 1 or 2, or claim 3, wherein the said condenser element has coaxial plates.

5. A device according to claim 4, wherein the beta particle emitter material is located within the inner plate of the said condenser.

6. A device according to any one of the preceding claims wherein the electrode structure of the tube is coaxial and the said condenser element is arranged within a space provided by a gap in the anode.

7. A device according to any one of the preceding claims wherein the gas or vapour filling of the envelope further contains a small amount of metastable gas.

8. A device according to any one of the preceding claims wherein the said beta particle emitter material consists of a radio-

isotope.

9. A device according to any one of claims 1 to 7, wherein the said beta particle emitter material comprises silicon 31, thallium 204 or a salt of these elements.

10. A device according to any one of the preceding claims wherein an auxiliary condenser is connected across the plates of the said condenser element.

11. A device according to claim 10 wherein the auxiliary condenser has a negative temperature coefficient.

12. A self-relaxation oscillatory device constructed and arranged substantially as herein described with reference to and as shown in the acompanying drawings.

MEWBURN ELLIS & CO.,
70/72 Chancery Lane,
London, W.C.2.
Chartered Patent Agents.

Berwick-upon-Tweed: Printed for Her Majesty's Stationery Office, by The Tweeddale Press Ltd.—1960.
Published at The Patent Office, 25 Southampton Buildings, London, W.C.2., from which copies may be obtained

845,240 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

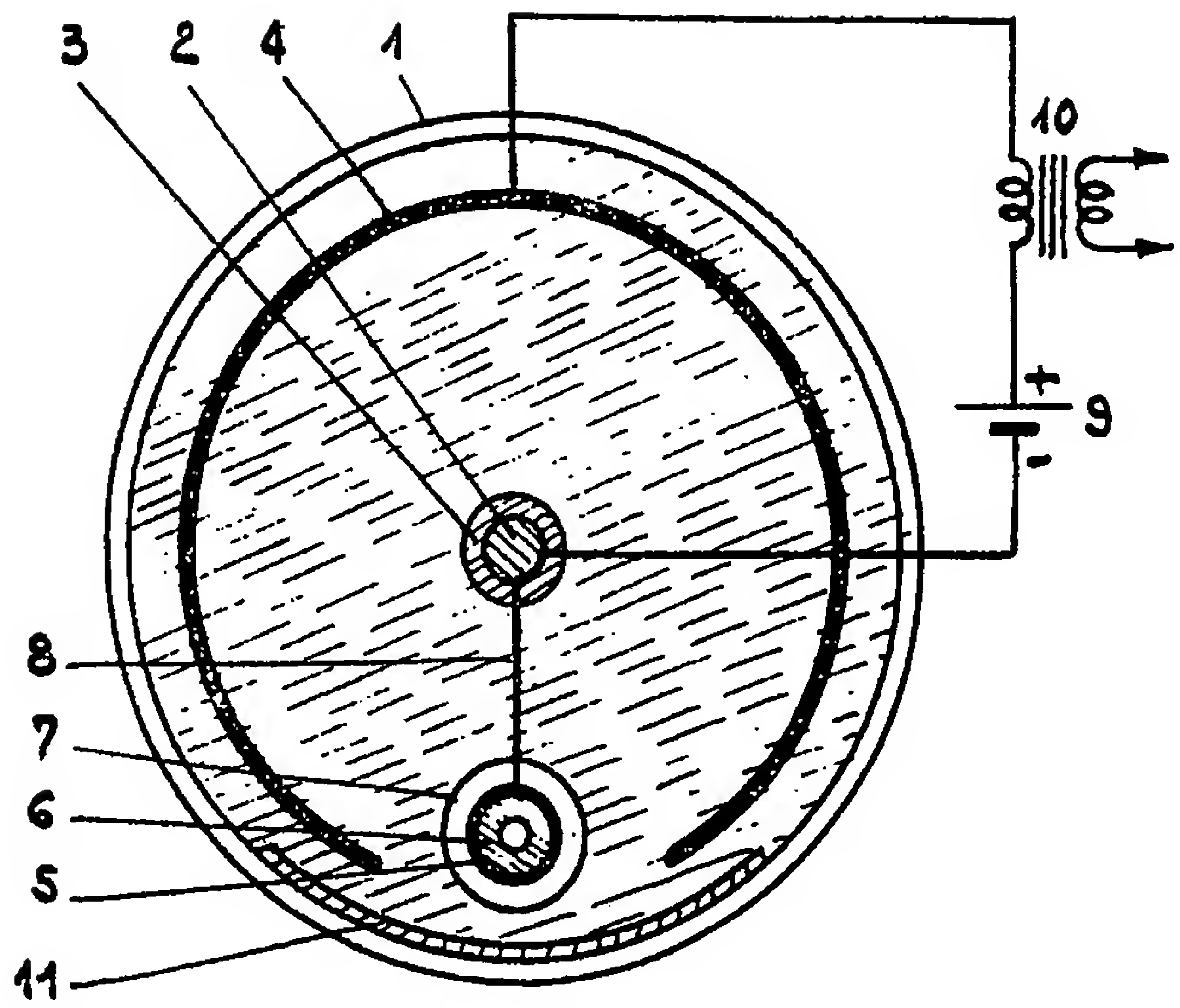

FIG.1

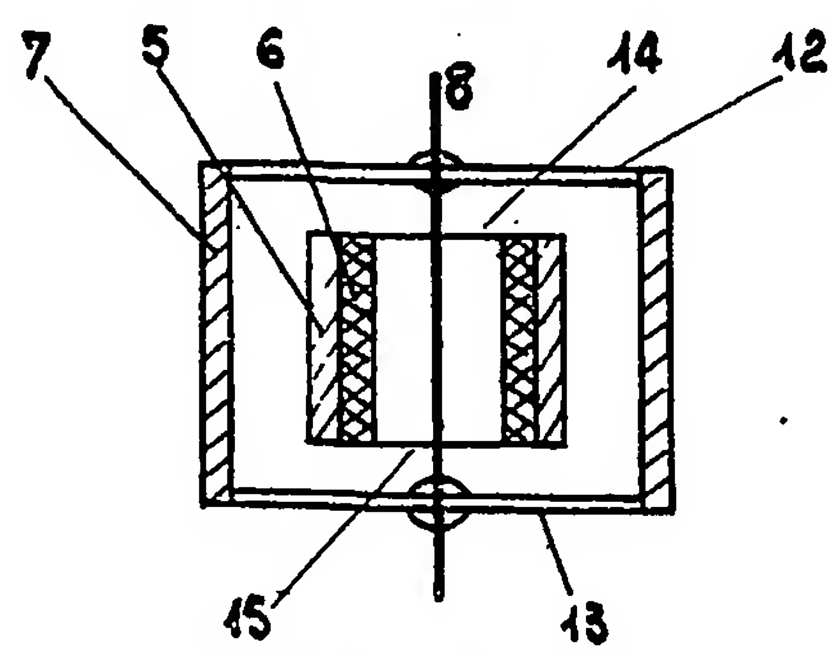

FIG.2